# Seasonal Ice Zone Reconnaissance Surveys Coordination

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## LONG-TERM GOALS

This grant is for the coordination of the Seasonal Ice Zone Reconnaissance Surveys (SIZRS) program of repeated ocean, ice, and atmospheric measurements across the Beaufort-Chukchi sea seasonal sea ice zone (SIZ) utilizing US Coast Guard Arctic Domain Awareness (ADA) flights of opportunity. The individual observational components of SIZRS are covered in separate reports. Our long-term goal is to track and understand the interplay among the ice, atmosphere, and ocean contributing to the rapid decline in summer ice extent that has occurred in recent years. The SIZ is the region between maximum winter sea ice extent and minimum summer sea ice extent. As such, it contains the full range of positions of the marginal ice zone (MIZ) where sea ice interacts with open water.

## OBJECTIVES

The overarching objectives for SIZRS are to:

- Determine seasonal variations in air-ice-ocean characteristics across the SIZ extending over several years and for a variety of SIZ conditions.
- Investigate and test hypotheses about the physical processes that occur within the SIZ that require data from all components of SIZRS.
- Improve predictive models of the SIZ through model validation and through the determination of observing system requirements.

## APPROACH

This grant coordinates the various SIZRS observations on the ADA flights, assure integration with modeling efforts, maintain the SIZRS website, serve as the SIZRS point of contact, and help gain the necessary Coast Guard approvals for the SIZRS instruments.

The U.S. Coast Guard Arctic Domain Awareness (ADA) flights offer the way to make regular measurements over long ranges in the Beaufort and Chukchi seas at no cost for the platform. SIZRS includes a set of core measurements needed to, make complete atmosphere-ice-ocean column measurements across the SIZ, make a section of ice conditions across the SIZ, and deploy drifting buoys to give time series of surface conditions. These operations and the relation of SIZRS to the

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Coast Guard mission are described by Hyles (2014). Our measurements are illustrated in Figure 1. Specifically, the core elements (Table 1) are aircraft expendable CTD (AXCTD) vertical profiles of ocean temperature and salinity plus aircraft expendable current profiler (AXCP) ocean velocity shear (Morison), UpTempO buoy measurements of sea surface temperature (SST), sea level atmospheric pressure (SLP), and velocity (Steele), and dropsonde measurements of atmospheric properties (Schweiger et al.), in-flight, and inflight laser profiling for ice thickness using the CU Laser Profiler Instrument-extended (CULPIS-X) (Tschudi, University of Colorado collaborating with Lindsay and Chickadel, UW). In addition, atmospheric modeling and ice-ocean modeling components (Schweiger et al.) will tie the SIZRS observations together. Other collaborating projects (Table 2) have come forward to participate in or collaborate with SIZRS, including buoy deployments for the International Arctic Buoy Program (Rigor, UW).

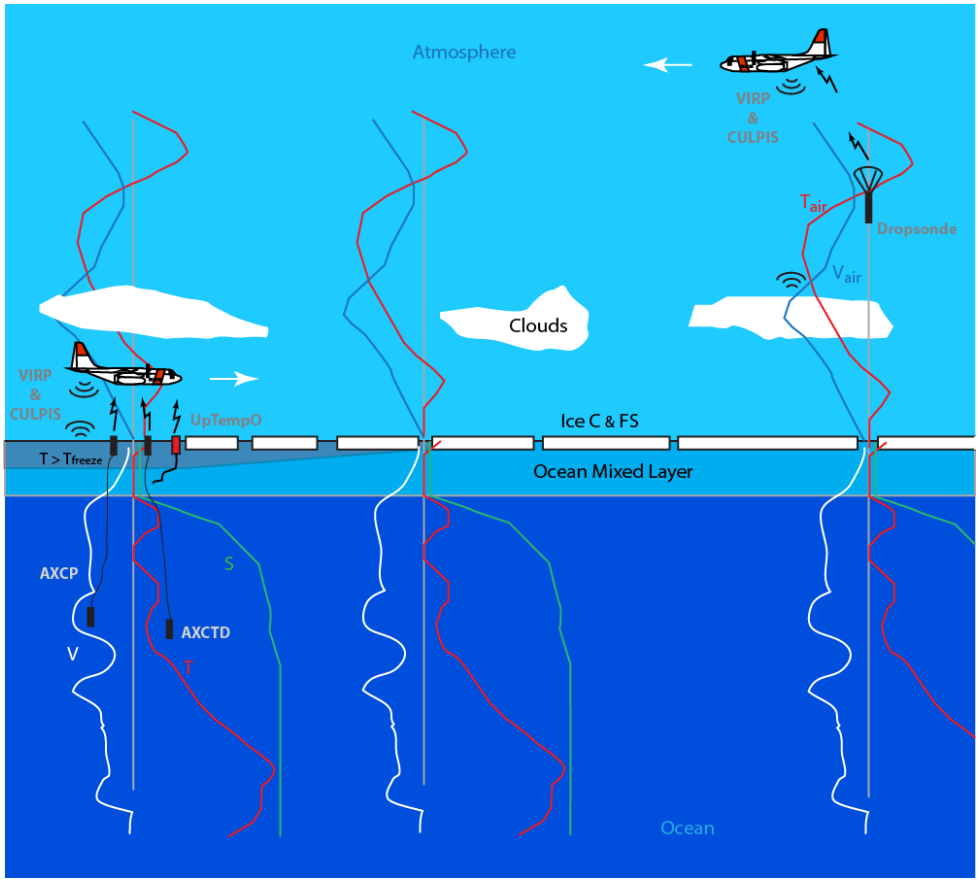


***Figure 1. Schematic of the SIZRS core measurements. The column measurements (AXCTD & AXCP at low altitude outbound & dropsonde at high altitude inbound) will be made in five locations (3 shown) with at least one column each in open water, MIZ, and pack ice. The aircraft remote sensing (CULPIS-X) will give sea ice concentration, floe size, and thickness and surface temperature profiles across the SIZ. Buoy deployments (core UpTempO and other IABP buoys) will provide time series at several locations across the SIZ. Missions will be flown monthly during the April-Oct time frame for three years***

ADA flights prior to this year were conducted twice per month from March through November. On ADA flights, we conduct atmosphere-ice-ocean observations at least once per month. This year, at our request, instead of two one day missions per month, the Coast Guard substituted single multi-day missions operated out of Fairbanks in July, August, and September. With forward staging like this, we have been able to conduct flights farther into the Arctic Ocean and on two lines of longitude (150°W and 140 °W) on consecutive days. These include lines of about 5 stations across the SIZ with profile measurements through the complete air-ice-ocean column (Fig. 1). UpTempO and IABP buoy deployments are made in June or when sufficient open water exists (e.g., August, 2014) and the buoy sites revisited with column measurements several times per season.

Flight paths are based on science priorities and on remote sensing estimates of ice conditions at the time of the flights. In general we focus on repeat sections on the 150°W and 140°W in order to provide interannual comparability. Remote sensing resources include MODIS visible and IR imagery, NSIDC ice extent charts based on a composite of passive microwave products (http://nsidc.org/data/masie/), and daily updated Oceansat-2 (OS2) scatterometer (a clone of QuikSCAT) from Son Ngheim at the Jet Propulsion Laboratory. Starting in 2013, we began a new component of SIZRS (Harry Stern, PI) to collect and analyze Arctic sea ice satellite visible imagery from the USGS Global Fiducials Library (GFL). These are provided a few days prior to flights for every degree of latitude from the Alaska coast up the 150°W longitude line into the ice up to about 80°N. They provide a record of ice conditions across the MIZ and help with preflight planning. We also receive regular images from the site of active AXIB or UpTempO buoys we deploy.

***Table 1: Core Projects of the SIZ Reconnaissance Survey Flights***

| Project | PI | Co-PIs | Observations/Activity |
|---|---|---|---|
| *Ocean Profile Measurements During the SIZRS* | **Morison** | | Ocean expendable probes AXCTD & AXCP for T, S, V, internal waves/mixing |
| *Clouds and the Evolution of the SIZ in Beaufort and Chukchi Seas* | **Schweiger** | **Lindsay, Zhang, Maslanik, Lawrence** | Atmospheric profiles (dropsondes, micro-aircraft), cloud top/base heights |
| *UpTempO buoys for understanding and prediction….* | **Steele** | | UpTempO buoy drops for SLP, SST, SSS, & surface velocity |
| *Visible and Thermal Images of the SIZ from the Coast Guard Arctic Domain Awareness Flights* | **Lindsay** | **Chickadel** | Analysis of visible and IR profiles using CULPIS-X (below) . Remote sensing for analysis and flight planning. |
| *High Resolution Satellite Visible Imagery for SIZRS* | **Stern** | **Schweiger** | Collect and analyze GFL visible imagery |
| Ice thickness and character using CULPIS-X | **Tschudi** | **Maslanik** | CULPIS-X Laser profiler for ice thickness, reflectance, skin temperature, visible imagery |
| AXCTD= Air Expendable CTD, AXCP= Air Expendable Current Profiler, SLP= Sea Level atmospheric Pressure, SST= Seas Surface Temperature, A/C= aircraft, SIC=Sea Ice Concentration | | | |

## WORK COMPLETED

SIZRS has nearly completed its third season working with USCG Air Station Kodiak. The coordination effort assembled documentation needed for USCG approval of all the originally proposed UW SIZRS instruments to be used on the ADA flights. The required Safety of Flight Tests (SOFT)* were successfully completed in February 2013, for the AXCTD and AXCP (Morison), dropsondes (Schweiger), and UpTempO buoys (Steele). The AXIB buoy of the IABP (Ignatius Rigor), which we deploy on some of our flights, had received approval prior to SIZRS. The CULPIS-X instrument from Tschudi at the University of Colorado has been in a complicated and long approval process since before SIZRS began. The process is lengthy for CULPIS-X because it requires temporary modification of the aircraft airframe. Given the uncertainty in the CULPIS-X approval process, the Lindsay and Chickadel infrared imagery project has purchased a commercial infrared video camera, and we have designed and built a mount that allows us to gather ice-ocean imagery from inside the aircraft when the rear loading ramp is down for the expendable probe and buoy deployments. We put his camera system successfully through its SOFT in February 2014, and we have been deploying it this year

Since our last report, we made one SIZRS flight in November of 2013 delayed due to the government shutdown. The results were limited to two stations due to limited daylight. Using the AXCTDs, AXCPs, the atmospheric Dropsondes we have conducted 7 SIZRS flights in 2014. These were on June 17, July 23 and 24, August 13 and 14, and September 25, and 26. We also dropped AXIB buoys on July 22, and September 23, and UpTempO buoys on July 24 and August 14. These operations began with flights originating in Kodiak, typically on Tuesdays, with the one-day mission on June 17 sampling on 150°W up to 76°N and terminating in Kodiak the same day. In the other missions, operating from Fairbanks has allowed longer missions sampling with AXCTD, AXCP and Dropsonde on both 140°W and 150°W up to 76°N and on September 24 an additional station at 77°N, 150°W to reach the pack ice edge. In these flights at least some sea ice was encountered at most stations, and along with poor visibility, presented the challenge of finding ice free leads into which we could drop the expendable probes. The USCG crews have been exceedingly good at meeting these challenges.

We coordinated with the ONR MIZ DRI to obtain various images in support of operations and SIZRS research. GFL high-resolution optical images were provided by the SCITOR Corporation and helped guide deployment. SAR imagery, providing detailed information about the evolution of the seasonal ice zone in the SIZRS region were obtained.

- (The SOFT is performed with a USCG C-130 on the ground at the USCGAS Kodiak ramp. The aircraft is run on the ground and all engine instruments and avionics readings are recorded. The test is repeated with all scientific gear connected as needed to the aircraft antennas and receiving and recording data. The SOFT is successful if the aircraft engine instruments and avionics instruments are not affected by the operation of the science equipment.)

## RESULTS

The scientific results are described in the report for the various scince components of SIZRS including for this PI “Ocean Profile Measurements During the Seasonal Ice Zone Reconnaissance Surveys”, grant number N00014-12-1-0236.

## IMPACT/APPLICATIONS

The SIZRS effort is a pioneering program in the use of aircraft expendable ocean and atmosphere sensor probes in tracking changes in the sea-ice environment of the Arctic. It will lead to greater availability of synoptic snapshots of environmental properties over extended ranges.

## RELATED PROJECTS

See Table 1.

## REFERENCES

Hyles, LT J., 2014, USCG Air Station Kodiak's Arctic Domain Awareness Mission Scientific Support Operations: A Vital Step Toward Arctic Understanding, blog of the U.S. Naval Institute, April 2014, http://blog.usni.org/author/jhyles.

## PUBLICATIONS

Hyles, LT J., 2014, USCG Air Station Kodiak's Arctic Domain Awareness Mission Scientific Support Operations: A Vital Step Toward Arctic Understanding, blog of the U.S. Naval Institute, April 2014, http://blog.usni.org/author/jhyles.